RESEARCH, DEVELOPMENT & TECHNOLOGY TRANSFER
QUARTERLY PROGRESS REPORT

Wisconsin Department of Transportation
DT1241 02/2011

INSTRUCTIONS:
Research project investigators and/or project managers should complete a quarterly progress report (QPR) for each calendar quarter during which the projects are active.

WisDOT research program category: ☐ Policy research ☒ Wisconsin Highway Research Program ☐ Other ☐ Pooled fund TPF#		Report period year: 2013 ☐ Quarter 1 (Jan 1 – Mar 31) ☐ Quarter 2 (Apr 1 – Jun 30) ☒ Quarter 3 (Jul 1 – Sep 30) ☐ Quarter 4 (Oct 1 – Dec 31)
Project title: Laboratory Study of Optimized Concrete Pavement Mixtures		
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WisDOT project ID: 0092-13-04	Other project ID: PRJ63JN	Project start date: 8/1/2012
Original end date: 1/31/2015	Current end date: 1/31/2015	Number of extensions: 0

Project schedule status:
☒On schedule ☐On revised schedule ☐Ahead of schedule ☐Behind schedule

Project budget status:

Total Project Budget	Expenditures Current Quarter	Total Expenditures	% Funds Expended	% Work Completed
199185	30349	156941	79	55

Project description:

The Wisconsin Department of Transportation (WisDOT) continues to investigate the feasibility of optimization of paving mixtures as a means to improve the engineering properties, lower the required cementitious materials content, reduce cost, and minimize the environmental impacts. Previous research conducted by WisDOT concluded that concrete produced with reduced cementitious materials content had an adequate durability; however, these mixes frequently demonstrated poor workability. As a result, a multi-faceted approach to optimizing mixture proportioning for low-slump mixtures used in concrete pavements is needed for WisDOT to realize the benefits related to the use of lower cementitious materials contents. This approach includes the use of supplementary cementitious materials (SCMs), optimized aggregate gradations, and the use of superplasticizers (high-range water reducing, HRWR admixtures). Current WisDOT practice minimizes the use of portland cement through replacement with SCMs, but does not address the use optimized gradation or superplasticizers. Therefore, additional research is needed to support the development of specifications inclusive of the aforementioned factors to improve the performance and sustainability of concrete paving mixtures used in Wisconsin. This research project evaluates the feasibility of expanding current specifications to incorporate optimized superplasticized concrete in sustainable concrete paving applications.

The goal of this study is to produce guidelines for optimized concrete mix design by evaluating the performance of a range of concrete mixtures. The proposed performance evaluation of optimized concrete will include workability (slump and VB-test), air content, unit weight, compressive and flexural strength, freeze-thaw resistance, and rapid chloride permeability in accordance with relevant AASHTO/ASTM standards. The results of the research will be used to recommend the aggregate gradations and dosage of superplasticizers/HRWR admixtures that will accommodate the use of reduced cementitious materials for the low-slump concrete paving mixtures.

To provide the comprehensive optimization of superplasticized concrete, the proposed project will focus on the following objectives:

1. Develop a detailed, final testing matrix for comprehensive testing of aggregate gradations, SCMs and HRWR admixtures in concrete.
2. Evaluate and compare the composition, microstructural features, and physical properties of different types of cementitious materials essential for their compatibility with HRWR admixtures affecting their performance in concrete.
3. Evaluate the effect of HRWR admixtures on the fresh properties and mechanical performance of concrete.
4. Evaluate the effect of aggregate gradations on the fresh properties and mechanical performance of concrete.
5. Evaluate the effect of SCMs and HRWR admixtures on the stability of air void system, fresh properties, mechanical performance, and durability of concrete.
6. Develop and recommend for practical application an express-method capable of evaluating the performance of SCMs and HRWR admixtures in concrete.
7. Provide Life Cycle Analysis of sustainable optimized concrete paving applications based on the experimental results; submit a final report and recommendations for future work and revision of current specifications.

Progress this quarter

During the 3rd Quarter of 2013, 12 batches (106 liter each) with optimal chemical and SCM types and dosages with one type of portland cement (produced in 2nd quarter) were shipped and tested at UW-Madison for rapid chloride permeability and freeze-thaw durability. These batches were also tested for compressive and flexural strength at 1, 3, 7, 28, and 90 days.

Additional work that was performed during the quarter included studying and synchronizing the optimal dosage of chemical admixtures previously used for benchmark (Lafarge) cement for two new types of cements.

17 preliminary concrete mixtures incorporating admixtures (20 liter volume) were produced with two new types of cements to test for fresh and hardened properties such as air content, fresh density, and mechanical behavior. The same admixture matrix and dosages used for the benchmark cement were applied for the new types of cements.

26 reduced (470 lb/yd^3 [279 kg/m^3]) and increased (520 lb/yd^3 [309 kg/m^3]) cementitious materials content concrete batches with different aggregates proportions were produced using the benchmark cement and tested for fresh and hardened properties and monitored for shrinkage. The effect of different aggregate proportions in reduced and increased cement content batches were investigated.

4 reduced cementitous materials content (470 lb/yd^3 [279 kg/m^3]) batches were produced and studied for fresh and hardened properties as well as length change with new types of cements.

Also, synchronizing the optimal dosage of chemical admixtures from mortars to concrete mixtures, and correlating early strength of mortar and concrete mixtures will be investigated. This follow-up step will further explore the empirical relationships between the results of express-tests and concrete properties and will evaluate the principal parameters affecting the performance.

The research team will provide the statistical analysis of experimental data; develop the relationships between the experimental factors and compare these with AASHTO/WisDOT/ACI requirements.

Anticipated work next quarter:

The Phase 1 work that is expected to be completed in the next quarter includes producing optimized big batches (106 liters) with new types of cements and current sets of aggregate. Big batches with further reduced cementitious materials quantities (420 lb/yd^3 [249 kg/m^3]) with all three types of cements and current set of Southern aggregates will be shipped to UW-Madison for durability testing.

Northern aggregates will be obtained for the Phase 2 investigation and the aggregate optimization studies will continue on new aggregates. Optimized mixtures with new aggregates will be studied. Durability tests that will be performed will include rapid chloride permeability and freeze-thaw testing for three sets of cements. Length change measurements due to shrinkage will also be continued.

Circumstances affecting project or budget: None

Attach / insert Gantt chart and other project documentation Enclosed

FOR WISDOT USE ONLY

Staff receiving QPR: K. Dinkins	Date received: 10/01/2013
Staff approving QPR:	Date approved:

Gantt Chart / Work Time Schedule